U. S. ARMY TEST AND EVALUATION COMMAND
COMMON ENGINEERING TEST PROCEDURE

IN-FLIGHT DISPERSION PATTERN MEASUREMENTS

1. OBJECTIVE

The objective of this test procedure is to obtain photographic instrumentation measurements of in-flight dispersion patterns of automatically fired projectiles.

2. BACKGROUND

Measurements of dispersion patterns for automatically fired projectiles at high weapon elevations can sometimes be obtained with conventional wooden targets. Such firings require a stable target and sufficient distance between the target and the weapon to avoid the effects of initial projectile yaw. Accuracy requirements of some tests may be incompatible with available target facilities. In this case, a photographic method can be used to obtain the required data. The photographic technique described in this procedure may be used to measure dispersion patterns in a plane perpendicular to the line of fire at approximately 500 feet from the weapon. This dispersion data are not immediately available, as in the case of firing against a target, but must be computed from the film measurements.

3. REQUIRED EQUIPMENT

a. Test Weapon
b. Bull's-eye targets (2 required)
c. Motion picture cameras with timing lights and film (2 required) capable of 5 frames per round.
d. Aiming target
e. Camera mounts (2 required)
f. Time base generator
g. Ammunition

4. REFERENCES

A. MTP 4-2-815, Photographic Instrumentation Characteristics.
B. MTP 4-2-816, Photographic Instrumentation for Trajectory Data.

5. SCOPE

5.1 SUMMARY

This document describes the engineering test required to determine the in-flight dispersion patterns of projectiles fired at high angles of fire using photographic methods. It also describes the methods for reducing and graphically presenting the data obtained.

5.2 LIMITATIONS

None

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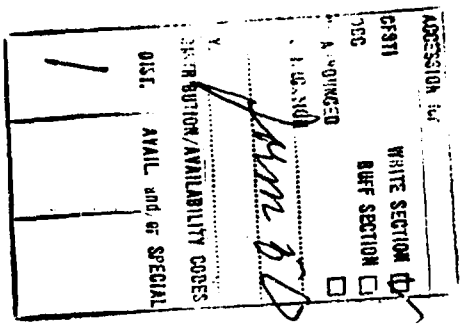


6. PROCEDURES

6.1 PREPARATION FOR TEST

6.1.1 Motion Picture Cameras and Mounts

Prepare and locate the cameras as described below (See Figure 1)

a. Emplace camera and mount number 1 approximately 10 feet to the rear of the weapon to obtain data on the azimuth or lateral, dispersion.

b. Emplace camera and mount number 2 approximately 20 feet to the flank of the weapon to obtain elevation dispersion measurements.

c. Assure that mounts permit adjustments in direction, tilt, and elevation angles.

d. Assure that cameras provide a minimum of five frames for each round fired.

e. Assure that both cameras are time correlated using a time base generator.

NOTE: The time base generator illuminates timing lamps within the camera at specific intervals and produces timing reference marks on the film.

f. Carefully measure and record the positions of the cameras in relation to the weapon and aiming point (Figure 2).

NOTE: The distances may be increased if the equipment or test results are placed in jeopardy by the weapon blast.

g. Assure that the optic axis of the rear camera is contained in the vertical plane of the weapon, with the elevation axis of the camera parallel to trunnion axis of the weapon. Both weapon and camera mount should be level.

h. Assure that the elevation axis of the flank camera is made coaxial with the elevation axis of the weapon.

6.1.2 Targets

Prepare and locate the targets as described below.

a. Emplace two bull's-eye targets and aiming target in front of the weapon.

b. Emplace the weapon aiming target so that it, together with the elevating axis of the flank camera, defines a horizontal plane.

NOTE: The distance from the aiming target to the weapon will establish the position along the trajectory of the reference plane for dispersion measurements. The bull's-eye targets provide a scale factor for evaluating the data and should be within the field of view of the cameras fairly close to the edge of the film frame.

c. The angular separation of the targets shall be measured to within a few seconds of arc from each camera position.

6.2 TEST CONDUCT

The test for measurement of in-flight dispersion patterns shall be conducted as follows:

6.2.1 Pre-Firing Preparation

Perform the following:

a. Sight the flank and rear camera on the weapon target (approximately 500 feet)
b. Sight the weapon on the weapon target.
c. Initiate both cameras and expose a few feet of film of the aiming target and check for calibration marks.

6.2.2 Firing

The firing shall be performed as follows:

a. Elevate the weapon to the desired angle.
b. Elevate the rear camera to the angle required to assure that its axis meets the reference plane of the axis of the weapon tube at firing elevation.

NOTE: The angle in step b, is computed from the geometry in figure 3; no superelevation is introduced in the weapon but corrections shall be applied to the data obtained.

c. Aim the flank camera at the weapon target without disturbing the direction of the camera mount elevation axis, i.e., the azimuth setting is not disturbed.
d. Elevate the flank camera to the firing elevation of the weapon.

NOTE: Ideally, the foregoing operations shall result in the optic axis of the flank camera being contained in a slant plane with the weapon, with the weapon tube axis and both camera axes meeting at the reference plane of measurements (i.e., a plane perpendicular to the weapon tube axis, which serves as a "target in space"). Since this is not always possible in practice, deviations from the prescribed setup should be measured and noted. These measurements are used as corrections in the data reduction process.

e. Start the cameras and begin firing a salvo. (The cameras are stopped after each salvo).
f. Perform calibration as described in 6.2.1 step c. after each day's firing.

6.3 TEST DATA

The test data to be recorded are as follows:

a. The identification of each round as they pass through the camera's field of view.

b. The azimuth deviations measurements for each round that appears on the rear camera (Figure 4).

c. The elevation dispersions that appear on the flank camera (Figure 5).

6.4 DATA REDUCTION AND PRESENTATION

Each round is measured on each frame in which it appears on the film. The measured values for any round, when plotted, fall in a straight line. The azimuth or elevation dispersion value for a particular round is obtained from the graph at the point where the line is nearest to the aiming point. This process is repeated for each round in the salvo.

a. The dispersion value for each round is corrected, as required, for lack of superelevation in the weapon (gravity drop) and for the difference in distance from weapon and rear camera to the target plane.

b. After all data are tabulated, a plot is made for each salvo (Figure 6). This plot shows each round's position, both in azimuth and in elevation. As the round passes through the target plane, it supplies a graphical representation of a simulated physical target firing. The calibration photographs show the aiming target and the calibration targets. Since the angles between the three targets are known, an angular value can be assigned to measured linear displacements. No significant error results from this process, since the fields of view are narrow and optical distortions are negligible.

NOTE: This method has an accuracy capability of ± 0.2 mil for dispersion measurements.

c. Calculate the dispersion measurements in accordance with MTP 4-2-815 and MTP 4-2-816.

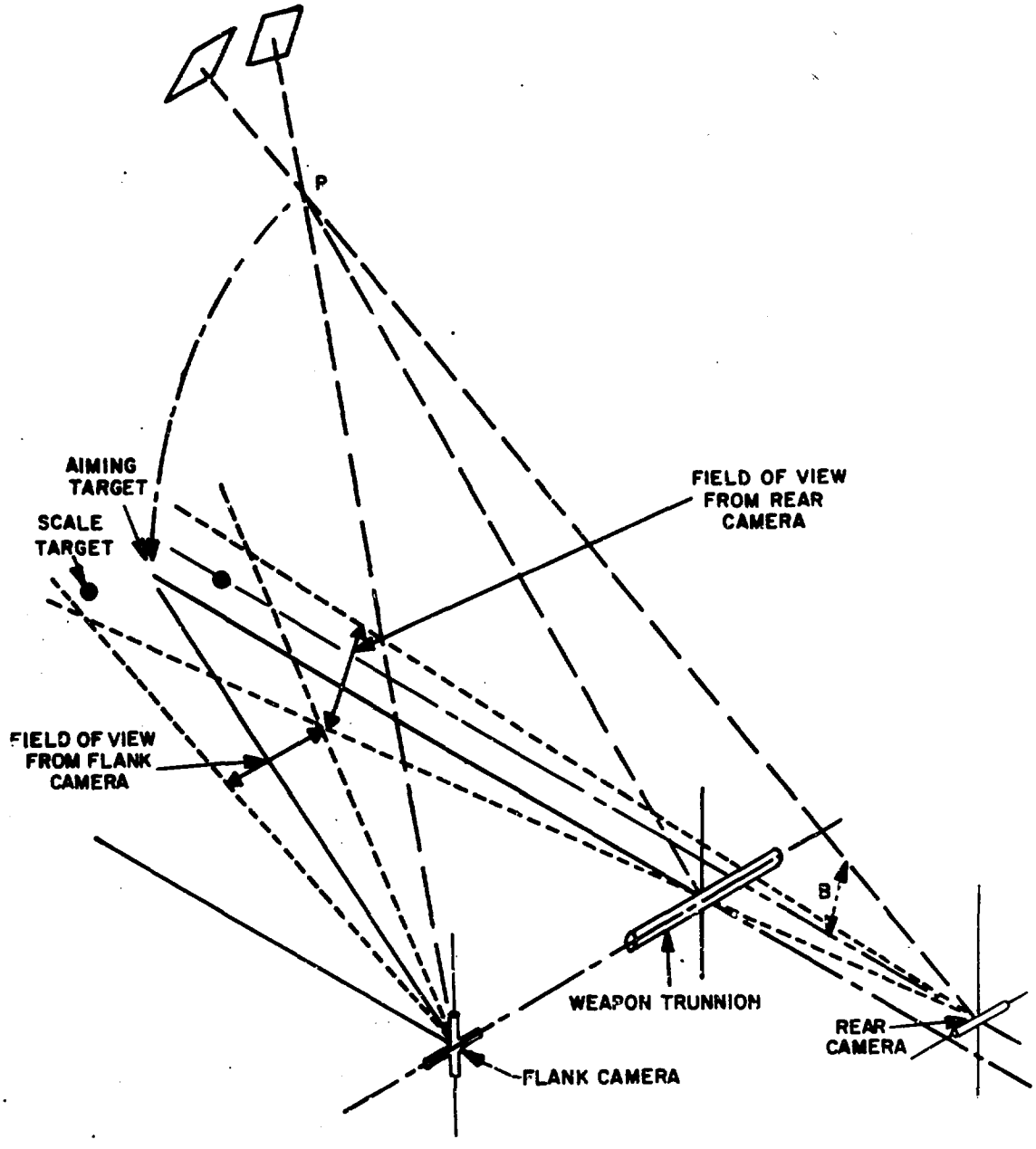
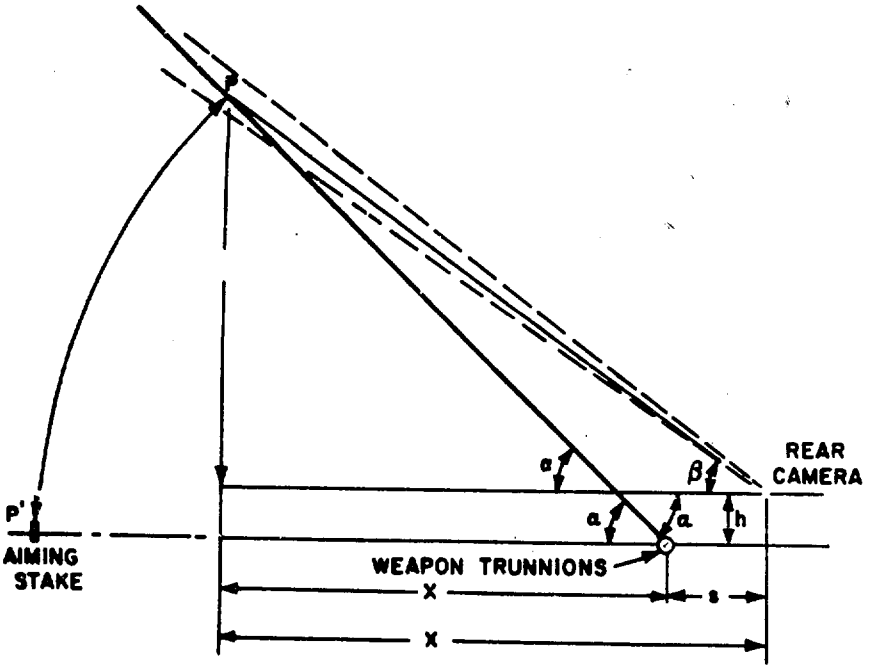


Figure 1. Schematic View of Weapon and Camera Arrangement

a. Rear Camera.



b. Flank Camera

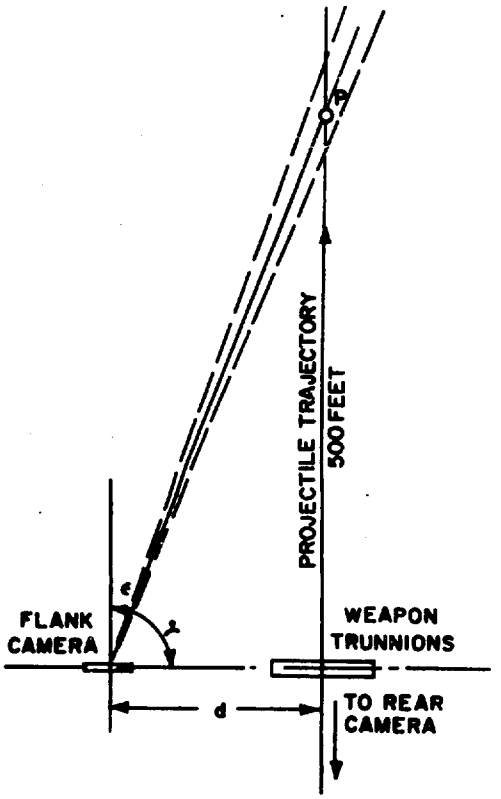


Figure 2. Diagrams Showing Measurements to be made in Determining Camera Elevation Angles.

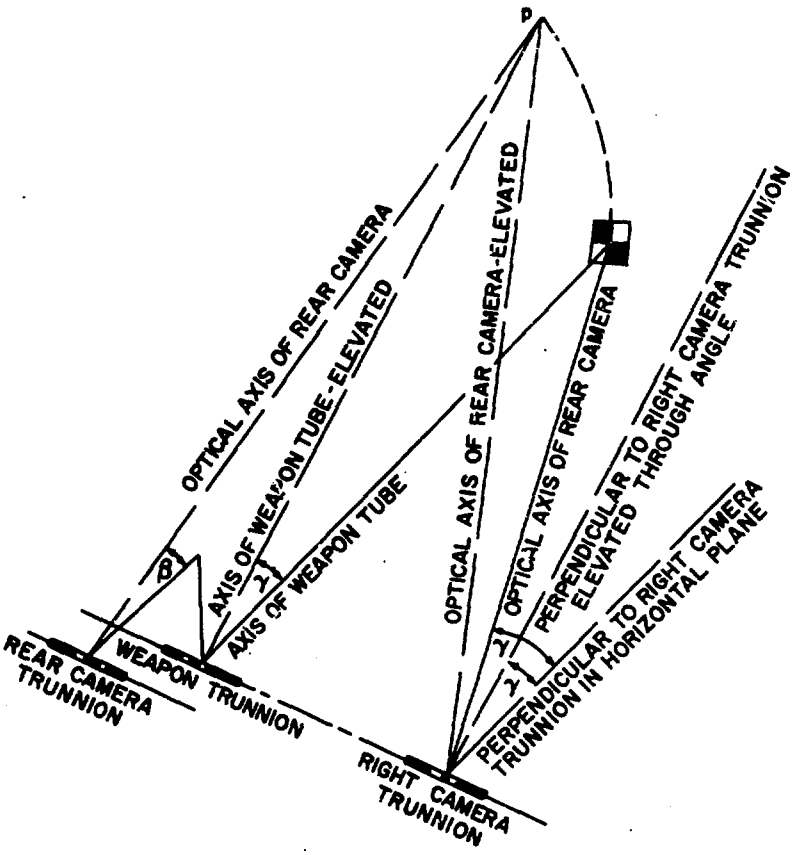


Figure 3. Angular Relationships Between the Optical Axes of the Camera and Axis of the Weapon Tube.

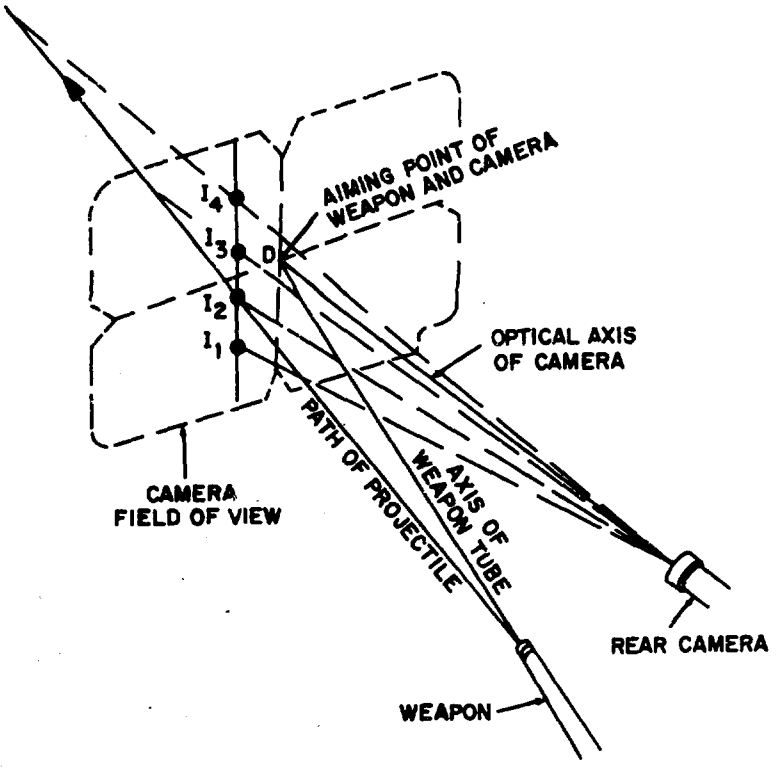


Figure 4. Function of the Rear Camera. The projectile is fired. As it passes through the field of view, successive images, I_1, I_2, I_3, and I_4, are exposed on successive frames of the rear camera. The distance, D, is the horizontal distance from the aiming point.

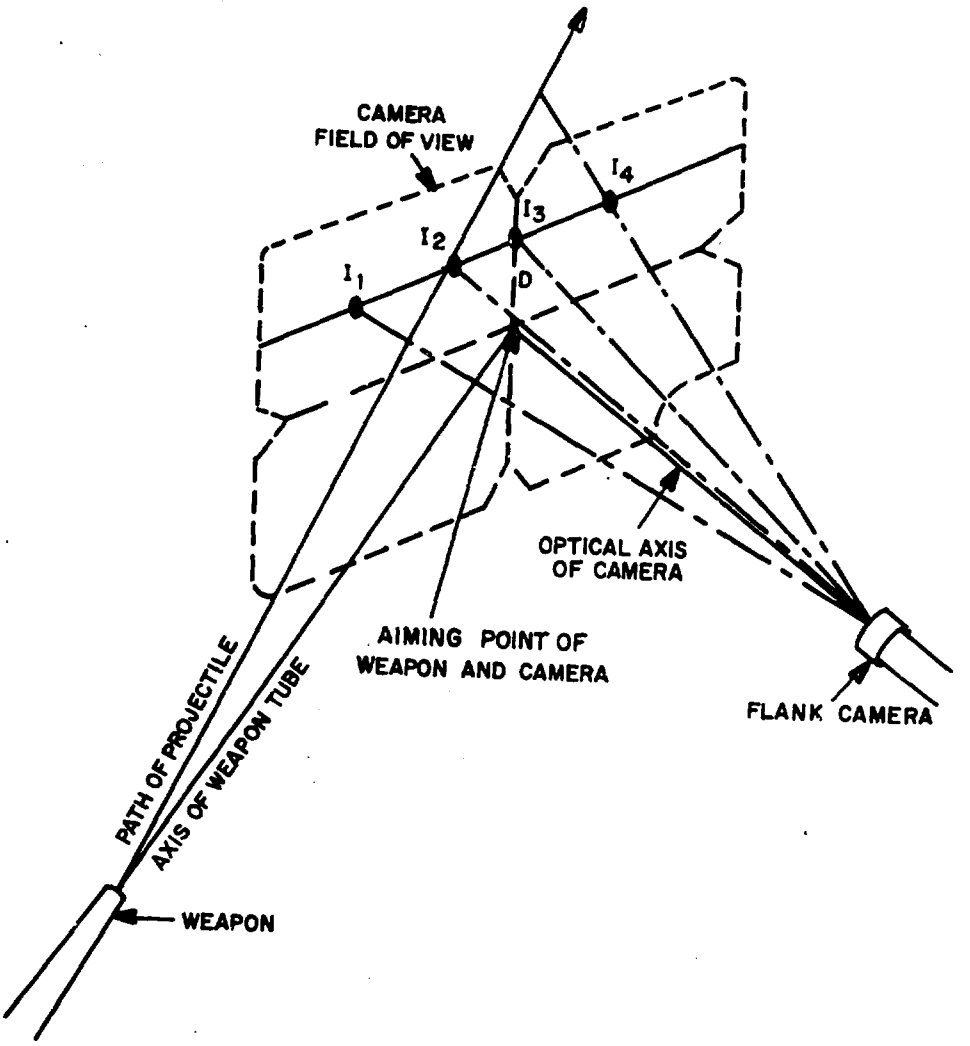


Figure 5. Function of the Flank Camera. The projectile is fired. As it passes through the field of view, successive images, I_1 , I_2 , I_3 , and I_4 , are exposed on successive frames of the flank camera. The distance, D, is the vertical distance from the aiming point.

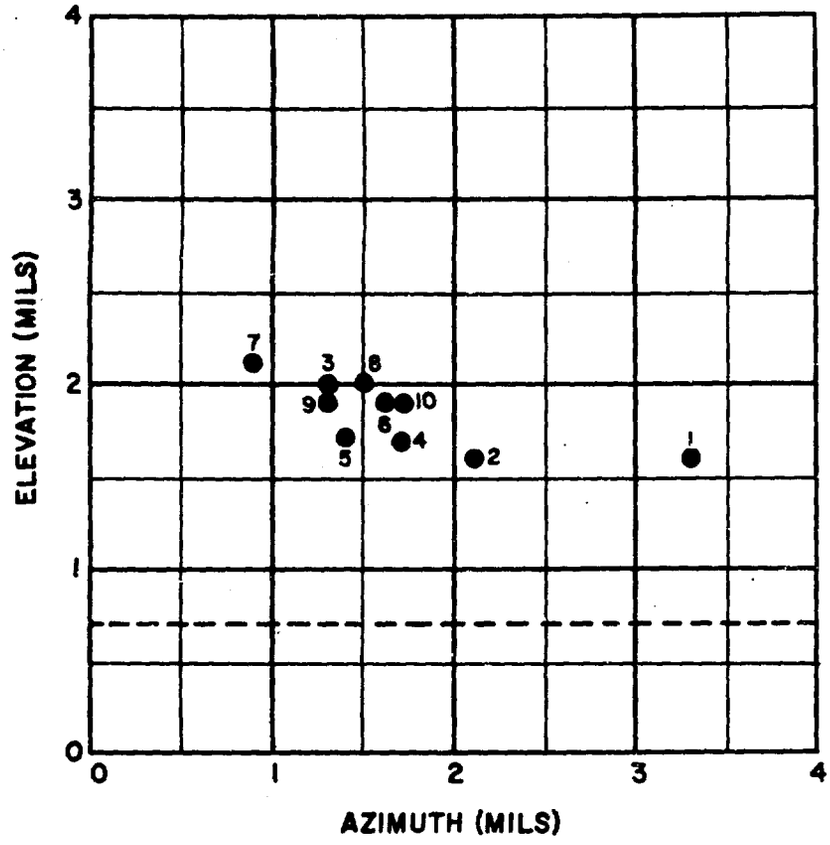


Figure 6. Dispersion of Rounds. The origin is the aiming point of the weapon with corrections made for gravity effects. The dotted line indicates the origin before gravity corrections have been made.